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ON THE OCCURRENCE OF TAILS IN MAN, WITH A DESCRIPTION OF THE CASE REPORTED BY DR. WATSON.

By Ross Granville Harrison, Ph. D., M. D.,
Associate Professor of Anatomy, Johns Hopkins University.

Some years ago Bartels[1] gave an excellent *resumé* of our [96 knowledge and beliefs concerning the occurrence of caudal appendages in man, showing that references to this peculiarity are to be found as far back as the writings of Pliny and Pausanias. Appended to Bartels' paper is a map, which shows the various lands supposed at one time or other to have been the haunts of human races with tails. These regions include not only widely distant portions of South America, Asia and Africa, but also the greater part of western Europe. While many of the statements cited by Bartels are to be classed as legendary, it is of interest to note how persistent and wide in range the belief in the existence of such races has been. The most remarkable stories have been told and have found credence; in these the significance of the caudal appendages has been variously interpreted. On the one hand, a tail has been considered a distinction of the highest degree, even a mark of divine descent, as in the case of the Ranas of Poorbunder;[2] on the other hand, it has usually been looked upon as a curse or a stigma of degradation.[3]

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[1] M. Bartels: Die geschwänzten Menschen. Archiv f. Anthropol., Bd. xv, 1884.

[2] These were the rulers of the Jaitwa or Camari, one of the Rajpoot tribes. "They trace their descent from the monkey-god Hanuman, and confirm it by alleging the elongation of the spine of their princes, who bear the epithet 'Pooncheria, or the long-tailed Ranas of Saurashtra.'"—James Tod: Annals and Antiquities of Rajast'han, or the Central and Western Rajpoot States of India, vol. i, London 1829.

[3] Bartels cites an instance of this in the stories regarding a certain

[96] While careful investigation of the many travellers' stories has invariably given negative results regarding the existence of tailed races, so many individual instances of *homo caudatus* have been observed, that the popular belief in them has been kept alive without difficulty. With the growing interest shown by anatomists and anthropologists in the subject, the number of cases which have been reported has become considerable, and the fact that the human embryo at a certain period of development is provided with a tail-like appendage has lent color to the discussion of the question. Bartels in 1884 referred to one hundred and sixteen persons who had recorded observations upon tailed men. Of these, over sixty cases had been more or less completely described. In 1892 Schaeffer[4] collected additional cases, adding in all twenty-five. Pyatnitski[5] has also given an elaborate account of the subject, and still more recently Kohlbrugge,[6] in connection with an admirable description of a very interesting case, has made valuable comparisons with previous work. From the United States five cases have, to my knowledge, been reported.[7]

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community of tailed men in Turkestan. These were held in the utmost contempt by the other people, and were therefore condemned to constant inbreeding. They were referred to as "Kuju rukly Tatar," which in German is rendered "*Stinkendes Ungeziefer mit Schwänzen.*" The tail was supposed to be a special curse in that it hindered the possessor from sitting properly on his horse.

[4] Oskar Schaeffer: Beitrag zur Aetiologie der Schwanzbildungen beim Menschen. Archiv f. Anthropol., Bd. xx, 1892.

[5] I. S. Pyatnitski: On the Question of the Formation of a Tail in Man, and of Human Tails in General, according to Data from Literature and Personal Researches. Dissertation. St. Petersburg, 1893 (Russian).

[6] J. H. F. Kohlbrugge: Schwanzbildung und Steissdrüse des Menschen und das Gesetz der Rüchscklagsvererburg. Natuurkundig Tijdschrift voor Nederlandsch-Indië, Deel lvii, 1898.

[7] Dickinson: A Child with a Tail. Brooklyn Medical Journal, vol. viii, 1894.

Halsted Myers: A Caudal Appendage. Proceedings of the New York Pathological Society, (1893) 1894.

Julian Berry: Baby with a Tail. Memphis Medical Journal, vol. xiv, 1894.

A. Ecker: Der Steisshaarwirbel (vertex coccygeus), die Steissbeinglatze (glabella coccygea) und das Steissbeingrübchen (foveola coccygea), Undoubtedly we have in these so-called tails a most heterogeneous collection of anomalies. [96] Anything appended to the sacral or coccygeal region is described as a tail. Many do actually bear certain resemblances to the tails of lower animals, and have in fact been compared with a great variety of these. On the other hand, some are vesicular or of irregular shape and accompany the condition of *spina bifida,* while others are to be classed as teratomata or other tumors. A further very significant fact is that a large proportion of the cases have been complicated by the coexistence of *ectopia viscerum, hypospadia, atresia ani,* or deformities of the limbs, all of which are known to result from amniotic adhesions. This circumstance has led Schaeffer to the conclusion that human caudal appendages are always due to this cause.[8]

There are, however, a great many cases in which the anatomical relations of the tail are such as to indicate that it owes its existence to the persistence of at least part of the vestigeal tail found in the human embryo. In some of these it seems that the coccyx extends down into the tail, though there is no good evidence that there is ever an increase over the normal number of coccygeal vertebræ in these instances. Under this latter head would come the majority of the adherent (*angewachsene*) tails described by Bartels,[9] and also some cases in which the tail projects free from the trunk as, for [97] instance, cases described by Braun,[10] Ornstein,[11] and by Dick-

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wahrscheinliche Ueberbleibsel embryonaler Formen, in der Steissbein- [96] gegend beim ungeborenen, neugeborenen und erwachsenen Menschen. Archiv f. Anthropol., Bd. xii, 1880. Ecker describes a case reported to him in a letter from Dr. Neumayer, of Cincinnati.

Miller: Medical and Surgical Reporter, 1881. (Not accessible.)

[8] Archiv f. Anthropol. Bd. xx, p. 219.

[9] M. Bartels: Ueber Menschenschwänze. Archiv f. Anthropol., Bd. xiii, 1881. In this paper Bartels classifies persistent tails, dividing them into two main types, adherent and freely suspended (*freie*); of the latter a number of subdivisions are made, between which, however, the distinc- [97] tion does not seem to me to be sharp.

[10] M. Braun: Ueber rudimentäre Schwanzbildung bei einem erwachsenen Menschen. Archiv. f. Anthropol., Bd. xiii, 1881.

[11] Ornstein: Schwanzbildung beim Menschen. Archiv f. Anthropol., Bd. xiii, 1881.

[97] inson. The majority of the embryonic tails contain, however, no prolongation of the vertebral column but are classed as what Virchow[12] calls soft tails (*weiche Schwänze*).

Description of Case.

About a year ago Dr. Watson exhibited before the Johns Hopkins Hospital Medical Society a baby with a tail, which is an example of the last-named class.[13] The tail was removed later, and through the kindness of Dr. Watson, who gave me the specimen as well as his notes of the case, I am enabled to make a fairly complete report on it, including a description of its histological structure.

The child, which was the third in the family, was a healthy, well-developed male. In its family history there is nothing which throws any light upon the case. Aside from the tail the baby presented only one other slight deformity, and that was in the four outer toes of the right foot. These toes were shorter than the normal ones of the left foot, their tips were turned up and the nails were small and thick. The phalanges of these toes were short and there were but two in each toe. The great toe of this foot was normally developed.

The tail appendage was attached in the mid-line about one centimeter below the tip of the coccyx. Examination of the sacro-coccygeal region showed a well marked *foveola coccygea* (Ecker) (Figs. 1 and 2), but owing to the extreme fineness of the hairs of this region, which to the unaided eye were quite invisible, it was impossible to distinguish any particular coccygeal bald spot or *glabella coccygea* (Ecker). Beginning a little to the right and below the *foveola* is a sharply defined groove, which runs obliquely downward and to the left between the buttocks and passes to the left of the root of the tail.

The appendage itself was of firm consistency, though con-

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[12] R. Virchow: Schwanzbildung beim Menschen. Deutsche med. Wochenschr., 10. Jahrg., 1884.

[13] W. T. Watson: Exhibition of a Three-months' Infant with a Caudal Appendage. Proc. J. H. H. Med. Soc. Johns Hopkins Hospital Bulletin, vol. xi, 1900.

taining no bone. It was covered with normal skin, containing fine hairs, and was apparently well vascularized. Three distinct portions or segments could be made out. The basal piece was short and on the dorsal side scarcely marked off from the next following, except when the tail was in a state of contraction (Fig. 2). On the ventral side a transverse furrow separated it from the next portion. The middle segment had a length of 25 mm., was curved a little to the right and tapered somewhat towards its distal end, where the much more slender end-segment was attached. These two portions were separated by a constriction more marked on the left side. The terminal segment curved to the right and ventrally and ended in a rounded blunt extremity. On the whole, the tail gave an impression not unlike that of a pig's tail, a similarity which has been noted in a number of cases previously reported. [97]

The hairs upon the tail, which were considerable in number, were plainly visible to the unaided eye. They pointed towards the tip, as could readily be confirmed by examination of longitudinal sections (Fig. 4). The convergence of the hairs towards the tip of the tail corresponds with the arrangement of the hairs in the coccygeal whorl (*vertex coccygeus* of Ecker), found in normal, *i. e.* tailless individuals, and supposed to be a vestige of the embryonic tail.

Two weeks after the birth of the child the tail was 4.4 cm. long; at the age of two months it had grown to 5 cm.; and at six months, when it was removed, it had attained the length of 7.0 cm., showing altogether a fairly rapid rate of growth.

The most remarkable characteristic of the tail was its movability. When at rest it would lie extended in the midline (Fig. 1), or bent over to one side upon the buttocks. The mother of the child said that she had seen the tail bent through an angle of 180°, its tip pointing towards the head. It must, however, have been brought into this position passively, for, as will be seen later, there was nothing in the arrangement of its muscles which could account for this. When the child was irritated, and cried or coughed, the tail would contract markedly. Between the basal and middle

[97] segments but little movement was possible; the contraction of the muscles merely brought out the constriction between the two portions more plainly. Between the middle and distal segments the movement was considerable. The latter could be drawn in sharply, telescoping the middle segment, and at the same time flexion to the left side took place. During this action the middle segment became much shorter and thicker.

When the child was about six months old the tail was removed by Dr. Watson.[14] The amputated appendage was put immediately into Zenker's fluid to harden. After it had been washed and kept in strong alcohol for some time it measured 5.3 cm. in length. It was then cut into four pieces with a sharp razor, and the pieces were imbedded in celloidin. Cross sections were cut at three different levels, near the base, proximal to the second joint, and near to the tip, as is indicated in Fig. 4. After a few transverse sections were cut off, the pieces were stuck together and reimbedded in celloidin for the purpose of cutting longitudinal sections of the whole.

From the study of sections it is seen that the skin covering the whole of the tail except a limited area on the ventral sur-
[98] face is of normal structure. The layers of the epidermis are easily distinguishable. The thickness of the skin varies somewhat. Near the base of the tail on the ventral side it is found to be quite 2 mm. thick, while on the dorsal surface of the same portion it is scarcely 1.5 mm. Further out, *i. e.* at the middle cut (Fig. 4, *a*), there is the same difference in thickness between skin of the ventral and dorsal surface (Fig. 5), although the skin is here not quite so thick as at the base. Near the tip the thickness throughout the whole

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[97] [14] It seemed advisable to remove the tail, not only in order to accede to the wishes of the child's parents, who regarded its presence with chagrin, but also on more practical grounds. It looked as if the tail might become the seat of a troublesome intertrigo. Besides, its rate of growth was considerable, and it did not seem unlikely that the appendage might have later attained undue proportions, causing, as has been reported in several instances, considerable inconvenience in sitting. (See Lissner: Virchow's Archiv, Bd. 99, 1885.

circumference is nearly 1.5 mm. The greater thickness of [98] the skin on the ventral side at the base is due principally to the epidermis, the corium being more nearly uniform throughout. In the thickened area the epidermal ridges extend down deep into the cutis, and the papillæ are very long and slender. The various integumentary organs, sweat glands, sebaceous glands and hairs, are numerous and of normal build. In longitudinal sections (Fig. 4) it may be very plainly seen that the hair follicles are obliquely inserted, the hair pointing towards the tip of the appendage. This is without exception the case in the proximal two-thirds of the tail, although the regular arrangement is somewhat disturbed at the crease where the distal and middle segments join, especially on the left side. The corium contains a very abundant supply of elastic fibres which may be readily demonstrated in sections stained by Weigert's method.

Beneath the skin the main bulk of the tail is made up of areolar tissue containing much fat. Blood-vessels, nerves, and striated muscle fibres are imbedded in this mass. There is no trace of anything like the medullary cord or of notochordal tissue, as Gerlach found in the tail of a fœtus of four months.

The voluntary muscle consists of a few bundles of fibres which take origin from the subcutaneous areolar tissue near the proximal end of the middle segment. They lie on the left side not far from the mid-line (Figs. 4 and 5), and run distally in parallel bundles diverging somewhat towards their insertion in the skin just beyond the joint between the middle and distal segments. The majority of the fibres are attached on the left side; a few, however, pass to the skin of the right side; and others are attached to the dorsal surface, and perhaps a few ventrally. The action of the muscle is thus clearly explained by its anatomical relations. There are no muscle fibres running between the trunk and the tail.

On the right side near the middle of the tail there are a few muscle fibres (Fig. 5, *M′*), but these are isolated in small bundles or as single fibres by a dense stroma of connective tissue. Moreover, nearly all of these fibres are in a state of

[98] degeneration. The fibrils are less distinct than usual, and the nuclei may be found scattered throughout the substance of the fibres. The muscle is, in fact, in an advanced stage of simple atrophy.

No one of the blood-vessels stands out preëminently in size. The largest artery is on the left side, held in place by strong connective-tissue bundles. This may be seen in sections through the middle (Fig. 5, *A*), as well as through the base of the tail. There are several smaller vessels in the vicinity. Two small arteries are seen in the right dorsal quadrant near the centre and one just beneath the corium, to the left of the mid-line. The veins are small and inconspicuous. There is nothing to be seen of a tuft-like branching of the vessels as Virchow[15] describes in one of his cases, nor is there anything resembling erectile tissue.[16] There is, however, an abundant supply of blood-vessels in the corium.

A number of small nerve trunks (Fig. 5, *N*) run longitudinally in the areolar tissue of the appendage. The majority of these accompany blood-vessels.

Similar Cases.—While it is not practicable to enumerate here all of the similar cases which have hitherto been reported, there are some which for one reason or other are of especial interest. The tail of a Moï,[17] ten years of age, which had attained the length of over twenty-five centimeters, is interesting on account of its size. Many of the cases have been described very briefly and only as regards external appearance. There are, however, a number of cases which have either been dissected or examined microscopically. These include Greve's case described by Virchow,[18] and cases reported by Meyers,[19] Vinogradow,[20] Rodenacker[21] and Scheboldayeff,[22] all of which agree with the present case in general [98] structure but differ from it in the absence of muscle. In two other cases, however, described by Pyatnitzki[23] and Gerlach,[24] respectively, striated muscle fibres were found, and it is to be assumed that such tissue was present in Neumayer's case, for the tail in this instance could be excited to reflex contraction by stimulation of the sacral region. The complicated arrangement of the muscles found in some instances is associated with the occurrence of bone, as in the case described by Hennig and Rauber,[25] and especially in Kohlbrugge's case.[26] The tail described by Gerlach in a fœtus of 4.6 cm. also contained a continuation of the notochord, which has as yet never been seen in older subjects.

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[15] Virchow's Archiv, Bd. 79, 1880.

[16] Bartels: Archiv f. Anthropol., Bd. xv, p. 116.

[17] Caudal Appendage in Man. (From the French of Étienne Rabaud, in "La Naturaliste.") Scientific American, vol. 50, 1889.

[18] Virchow's Archiv, Bd. 79, 1880.

[19] Proc. N. Y. Pathol. Soc., 1893.

[20] K. N. Vinogradow: On Human Tails. Vrach, vol. xv, 1894 (Russian).

[21] G. Rodenacker: Ueber den Säugethierschwanz mit besonderer

THE TAIL IN THE HUMAN EMBRYO.

The caudal region in human and other mammalian embryos has already been described by Ecker, His, Keibel, Fol, Braun and others. These accounts, while agreeing in the main, bring out considerable differences of opinion as to details. For this reason I give here a further description of the tail region in several human embryos. This I am enabled to do [99] through the kindness of Dr. Mall, who placed at my disposal his fine collection of human embryos. Two specimens, fourteen and sixteen millimeters long respectively, were found to be especially adapted for this purpose, for it is at this stage that the tail reaches the highest point in its development. The study of these was greatly facilitated on account of their excellent state of preservation, and by the fact that they were cut into perfect series of sagittal sections.

Berücksichtigung der caudalen Anhänge des Menschen. Inaug.-Diss., [98] Freiburg i. Br., 1898.

[22] W. Scheboldayeff: Tailed Men. Zemsk. Vrach, vol. vi, 1893 (Russian).

[23] Inaug.-Diss., St. Petersburg, 1893.

[24] L. Gerlach: Ein Fall von Schwanzbildung bei einem menschlichen Embryo., Morphol. Jahrb., Bd. vi, 1880.

[25] C. Hennig and A. Rauber: Ein neuer Fall von geschwänztem Menschen. Virchow's Archiv, Bd. 105, 1886.

[26] Natuurkund. Tijdschr. v. Ned. Indië, Deel. lvii, 1898.

[99] *Embryo 144. Greatest Length 14 mm.; Neck-Breech 12 mm.* —The tail of this embryo is marked off ventrally by a fold of epithelium which extends cranially from the anus, forming a shallow pit or crease between the anal prominence and the tail. This fold extends to the level of the cranial end of the thirty-third vertebra (Fig. 6), so that from this point on, *i. e.* distal to the third coccygeal vertebra, the caudal end of the embryo projects free from the trunk.

The vertebral column extends throughout but half the length of the tail, in which, therefore, a vertebral and non-vertebral portion may be distinguished.

The terminal portion of the tail or caudal filament is bent dorsally and inclined to the left side, and becoming rapidly thinner distally, ends in a slight knob-like enlargement, which is scarcely shown in the figure. The most conspicuous structure in the caudal filament is the medullary cord, which runs to the tip and there ends in a vesicular enlargement. The notochord and the terminal branches of the aorta and inferior vena cava also extend out into it though not so far as the medullary cord. The filament is supported by a diffuse mesenchymatous network, more concentrated in the ventral side just beneath the integument, which is perhaps an indication of the remains of the post-anal gut found in younger embryos.

Counting from the atlas down, it is clear that there are in all thirty-six vertebræ present, of which the distal seven belong to the coccygeal or caudal region. In the trunk, down through the sacral region, the vertebral bodies are composed of embryonic cartilage, which does not stain intensely. The intervertebral discs, owing to the greater concentration of the cells composing them, stand out in sections as deeply staining bands. Between the vertebral bodies and the discs there is a zone of cells, which stains more intensely than the cartilage and less so than the discs. In the well advanced vertebræ of the lumbar region the intermediate zone is thin and clearly forms a part of the perichondrium of the vertebral cartilages. Beginning with the first coccygeal vertebra this intermediate or perichondrial layer forms a thick pad, especially on the distal surface of the disc. The vertebral body is [99] here proportionately thin, showing itself merely as a lighter streak between the more deeply staining perichondrium of each end. In fact the bodies of the distal coccygeal vertebræ can hardly be spoken of as cartilaginous. In thickness (craniocaudal) the vertebral bodies diminish steadily throughout the sacral and coccygeal regions, but there is very little diminution in the dorsoventral diameter until the thirty-fourth vertebra is reached. The last three diminish rapidly towards the tip. In the last two the discs are fully as thick as the vertebral bodies themselves. The distal surface of the vertebra is capped by a well marked disc. There is on each side of the intervertebral discs in the coccygeal region a small mass of deeply staining tissue, which projects ventrally and laterally. They are visible only in sections which pass to the side of the mid-line. They represent undoubtedly rudimentary hypapophyses or hæmal arches found in the caudal vertebræ of lower forms.

The spinal ganglia, not counting the ganglion of the hypoglossus, are thirty-three in number. In connection with the last a distinct ventral ramus arises and passes ventrally to the side of the vertebræ, bending distally; ventral to the vertebræ it joins a trunk from the next higher nerve. Its mode of ending is uncertain.

The number of muscle plates could not be made out clearly.

In the interval between the thirty-first and thirty-second vertebræ the medullary cord (*med.*) becomes suddenly attenuated into a *filum terminale.* There are apparently few or no neuroblasts beyond this point; the walls of the tube are made up of columnar epithelial cells. In the distal portion of the vertebral region and at the base of the caudal filament the cord takes a somewhat sinuous course. The central canal extends to the tip of the tail, where it ends in the slight enlargment mentioned above, the terminal ventricle.

The notochord (*ch.*) forms the axis of the vertebral bodies and discs, and in the proximal portion of the coccygeal region, as in the trunk, is almost straight. In the region of the last two or three vertebræ it is more tortuous. It leaves the

[99] vertebral column near the dorsal surface of the last vertebral body and passes thence dorsally to the ventral side of the medullary cord, accompanying this nearly to the tip. In contrast to the vertebral portion, the terminal portion is scarcely differentiated and not well defined in the surrounding mesenchyme.

The continuation of the aorta (*ao.*), *i. e.* the *a. sacralis media,* at first ventral to the vertebræ, passes out into the caudal filament as an *a. caudalis.* From this are given off the segmental arteries, one for each vertebra down to and including the last or thirty-sixth. (The last two are not shown in the figure.) These pass up on each side of the vertebral bodies, but it is doubtful if the more distal ones are as yet fully open. In the same way the vena cava continues into the tail, as the *v. sacralis media* and the *v. caudalis,* which lies ventral and to the right of the artery. At their termination in the caudal filament the artery and the vein meet. The vein is of large calibre to the region of the thirty-second vertebra; here it narrows down very suddenly. There are numerous small blood-vessels throughout the mesenchyme of the tail.

Embryo 43. Greatest Length 16 mm.; Neck-Breech Length 14 mm.—The relations of the tail to the trunk are about the same as in the younger embryo first described, *i. e.* it is free from the thirty-third vertebra on.

The vertebral portion of the tail is longer, but the caudal
[100] filament is shorter and more shrunken. It bends sharply on itself to the dorsal side, almost through an angle of 180°.

Thirty-seven vertebræ are present, with possible indications of a thirty-eighth; eight of these belong beyond doubt to the coccygeal region. The thirty-fourth and thirty-fifth are partly fused in the middle. The hypapophyses of each are distinct.

The spinal ganglia number thirty-two. The relations of the notochord, medullary cord and blood-vessels are the same as in the embryo first described. There is a slight irregularity in the notochord in the form of a process which extends ventrally into the substance of the thirty-sixth vertebra.

Ecker[27] and His[28] were the first to give detailed descriptions of the caudal region of the human embryo. Their conclusions regarding its definition and ultimate development may be taken as the starting point in the discussion of the subject. The agreement reached by Ecker and His may be rendered in part as follows:[29] (1) The term "tail" may be applied only to that portion of the embryo which projects free beyond the cloaca. (2) The tail consists of a portion containing vertebræ and a portion without vertebræ (caudal filament). The latter contains only notochord and medullary cord. (3) Only the non-vertebral portion atrophies. The vertebral portion remains for some time as the coccygeal prominence (*Steisshöcker*), which, however, gradually disappears in consequence of the increase in the curvature of the sacrum and coccyx, and of the progressive development of the pelvic girdle and its musculature.

Two matters which have a bearing upon the morphological significance of the persisting caudal appendages in man are brought up in the above for consideration. The one concerns the structure of the tail in the human embryo in comparison with the tail in lower forms; the other is the nature and amount of regressive change which takes place in the human tail during development.

Regarding the first, Keibel[30] discovered an additional fact of importance in the presence of a post-anal gut in the human embryo. Braun's[31] observations on the caudal filament of

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[27] A. Ecker: Archiv f. Anthropol., Bd. xii, 1880.

A. Ecker: Besitzt der menschliche Embryo einen Schwanz? Archiv f. Anat. u. Physiol. anat. Abtheil., 1880.

[28] W. His: Anatomie menschlicher Embryonen, I, Leipzig, 1880.

W. His: Ueber den Schwanztheil des menschlichen Embryo. Archiv f. Anat. u. Physiol. anat. Abtheil., 1880.

[29] A. Ecker: Replik und compromissitze nebst Schlusserkärung von W. His. Archiv f. Anat. u. Physiol. anat. Abtheil., 1880.

[30] Fr. Keibel: Ueber den Schwanz des menschlichen Embryo. Archiv f. Anat. u. Physiol. anat. Abthiel., 1891.

[31] M. Braun: Entwicklungsvorgänge am Schwanzende bei einigen Säugethieren mit Berücksichtigung der Verhältnisse beim Menschen. Archiv f. Anat. u. Phys. anat. Abtheil., 1882.

[100] mammalian and bird embryos are of importance in showing that the caudal filament is of general occurrence and not a peculiarity of the human tail. Again, the occurrence of spinal nerves and ganglia in a number of the coccygeal segments, as shown by Fol,[32] Phisalix[33] and Keibel, the continuation of the aorta and vena cava into the caudal filament, together with the presence of segmental arteries and the hypapophyses or rudimentary hæmal arches in all of the coccygeal segments as described in the present paper, show that the caudal region of the human embryo resembles that of other mammalian embryos in all respects except in size and in the number of its segments.

Concerning the regressive development of the tail considerable difference of opinion has been expressed. Rosenberg, who holds that, strictly speaking, the caudal rudiment in man is not the homologue of the tail of other animals, but is the result of a precocious growth of the medullary cord,[34] considers that the appendage disappears in consequence of the increase in volume of that end of the embryonic body and not through absorption. His,[35] in supporting Rosenberg, makes the statement that no reduction in the number of segments takes place during the development of the human embryo, but that the regressive changes are confined to the caudal filament; this view is confirmed in the agreement with Ecker. On the other hand, Fol and Phisalix find thirty-eight segments in embryos of 8-10 mm., with indications that sev-

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[32] H. Fol: Sur la queue de l'embryon humain. Comptes Rendus, T. 100, Paris, 1885.

[33] C. Phisalix: Étude d'un embryon humain de 10 millimètres. Archives de Zool. Exp. et Gén. IIme S., T. vi, 1888.

[34] E. Rosenberg: Ueber die Entwickelung der Wirbelsäule und das centrale carpi des Menschen. Morphol. Jahrb., Bd. i, 1876. "... dass die Gestaltung des hinteren Leibesendes ebenfalls von dem Medullarohr derart beeinflusst wird, dass letzteres, indem es in seinem Längenwachsthum dem der anderen, un der Zusammensetzung des hinteren Leibesendes Theilhabenden Bestandtheile vorauseilt, an demselben einen Vorsprung erzeugt. ..." p. 128.

[35] "Es werden demnach beim menschlichen Embryo keine überzähligen zur Rückbildung bestimmten Segmente angelegt." Anatomie menschlicher Embryonen, i, p.92.

|100| eral of these disappear through fusion in the course of development. Allowing for the possibility that these observers have counted in an occipital segment, there would be in embryos of this size at least thirty-seven trunk segments, which would correspond to thirty-six vertebræ. Keibel finds in an embryo of 8 mm. thirty-five trunk segments, together with a mass of unsegmented mesoderm, equaling two segments in length. Reckoning this as two instead of one segment, as Keibel does, we have again thirty-seven segments, corresponding to thirty-six vertebræ.

The following is an attempt to tabulate the number of segments found in embryos varying in length from 7.5 to 21.5 mm. With the exception of the last column the data are as recorded by the observers themselves. In the last column the number of vertebræ is given which would correspond to the total number of segments after certain changes have been made, such as deduction of occipital segments or addition of unsegmented mesoderm, which seemed justified by the descriptions of the authors.

[101]

Observer.	Length of embryo in mm.	Segments in mesoderm.	Spinal ganglia.	Vertebræ.	Corresponding number of vertebræ after allowing for corrections.
His	7.5	35	—	34	34
Keibel......	8.0*	35 + unsegmented mesoderm.	—	—	36†
Fol.........	8.0–9.0	38	—	36	36
Phisalix	10.0	38	36	..	36
Keibel......	11.5*	35 + unsegmented mesoderm.	34	35	36†
Fol	12.0	..	—	36	36
Harrison ...	14.0	..	33	36	36
Harrison ...	16	..	32	37	37
His	16.0	..	..	34	34
Rosenberg ..	16.5	..	..	33	33
Fol	19.0	..	..	34	34
Rosenberg ..	19.0	..	..	35	35
His	21.5	..	..	34	34

* Neck-breech measurement.

† Counting the terminal mesoderm as equivalent to two segments.

[101] From this it may be seen that the number of vertebræ or their equivalent is fairly if not quite constant in embryos between eight and sixteen millimeters in length. We have, then, seven vertebræ in the embryonic tail at its highest period of development. The stages studied by His and by Rosenberg were either too young or too far advanced to show the maximum number of vertebræ. That the reduction takes place by fusion, as is maintained by Fol, is confirmed by the study of the embryos described above. In the older embryo (16 mm.), in which an exceptionally large number of segments was present, partial fusion between several of the adjacent vertebræ had taken place. In still older embryos, as seen in the table, the number of segments is inconstant; most probably this is due to the varying extent to which fusion has taken place, though it is possible that it may be due in part to a difference in the original number. As Steinbach[36] shows, the usual number of segments is thirty-four, *i. e.* five coccygeal, although the number may be less or, in rare instances, even increased by one.

The spinal ganglia of the caudal region, as Keibel has shown, also suffer reduction. There are never quite so many ganglia developed as vertebræ, and the last ones are always more or less rudimentary; but there are always more formed than persist in the adult. For instance, in an embryo of 10 mm. Phisalix described thirty-six ganglia; in an embryo of 11.5 mm. Keibel found thirty-four; in the embryo of 14 mm. described above there were thirty-three, and in the embryo of 16 mm. thirty-two, while in the adult there are but thirty-one. The segmental arteries of the distal caudal segments also become obliterated as development proceeds.

We conclude, then, with Keibel that, while as far as outward form is concerned the embryonic tail disappears largely as a result of the growth of the extremities and the gluteal region, a certain amount of regressive change takes place in the caudal appendage itself. This is manifest not only in the absorption of the caudal filament, as supposed by Ecker and

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[36] E. Steinbach: Die zahl der Caudalwirbel beim Menschen. Inaug. Diss., Berlin, 1889.

His, but also in the reduction of all essential structures of [101] the vertebral portion of the tail, *i. e.* the vertebræ, muscle segments, spinal ganglia and blood-vessels. It is interesting to note that in this tendency to reduction the resemblance between human and other mammalian tails also holds. The caudal filament, as Braun has shown, is present in other embryos and atrophies as development proceeds. The tendency to fusion of the distal vertebræ has been observed in the embryos of various long-tailed animals. And in short-tailed varieties, as Bonnet has shown, this tendency is merely accentuated.[37]

The view that a great many of the anomalous caudal appendages found in man are, as stated in the beginning, due to the persistence of the embryonic tail, is warranted by the facts gathered both from the study of the former as well as of the latter. Many of the differences in form are explained by the hypothesis of Bartels that the embryonic tail may be arrested in any stage of its development. The soft or boneless tails are clearly not due to the multiplication of vertebræ or even to the persistence of all which are developed in the embryo, but, as His[38] first suggested, are to be regarded as persisting caudal filaments. The usual position of these appendages as well as their structure support this conclusion. The fact that they are not always attached exactly over the tip of the coccyx cannot be regarded as conflicting with this view, for, as has long been recognized, the curvature in the vertebral column, especially in the sacral and coccygeal regions, changes markedly during development, and the caudal filament not being firmly united to the tip of the coccyx might easily be shifted slightly in relation to the latter.

In the action of amniotic adhesions Schaeffer[39] has suggested a cause which may undoubtedly bring about the persistence of the caudal filament, for it is a fact that in many,

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[37] R. Bonnet: Die stummelschwänzigen Hunde im Hinblich auf die Vererbung erworbener Eigenschaften. Zeigler's Beiträge z. path. Anat. u. allg. Pathol., Bd. iv, 1889.

[38] Anatomie menschlicher Embryonen, i, p. 95.

[39] Archiv f. Anthropol., Bd. xx, 1892, p. 219.

[101] perhaps in a majority of the cases there are other evidences of such adhesions having been present, and, as Schaeffer points out, the caudal region, like other projecting portions of the embryo, is especially liable to stick to the amnion. The adhesions are to be regarded, however, merely as a factor which may induce the persistence of an otherwise transitory structure and it does not follow that such persistence is always the result of adhesions. On the contrary, we find in certain animals that the caudal filament normally persists. According to Braun, this is probably the origin of the tail-stump, composed of areolar tissue, found in Inuus pithecus, and similar apendages are also found sometimes in the Chimpansee, as Rosenberg has described.

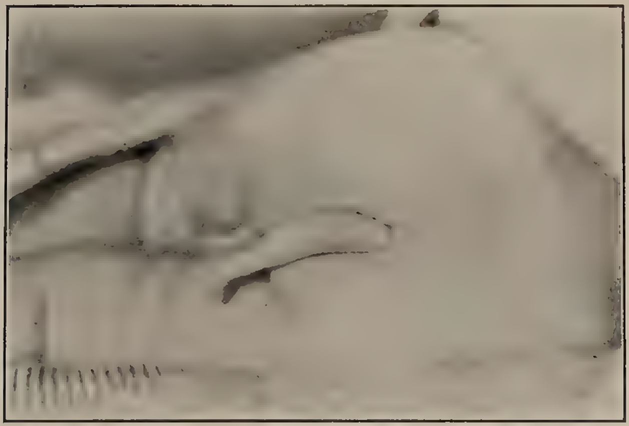

FIG. 1.—Photograph showing tail in extended condition.

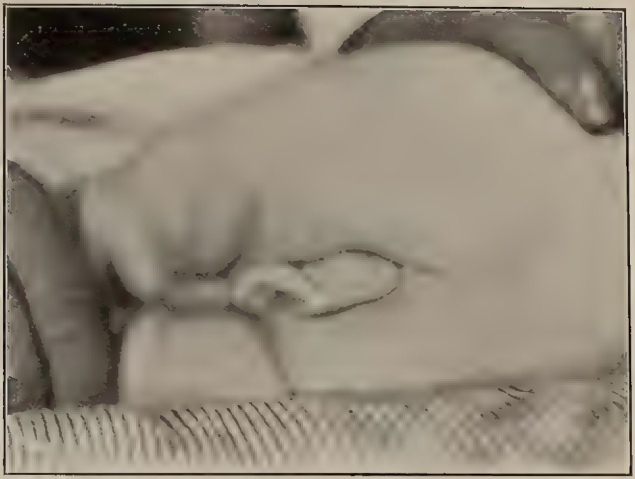

FIG. 2.—Photograph showing tail in state of contraction.

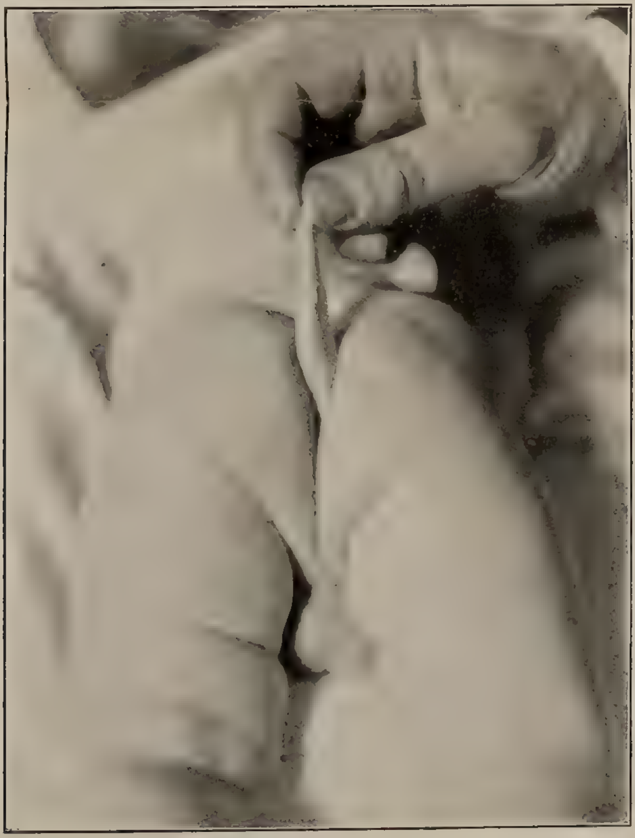

FIG. 3.—Photograph showing the ventral surface of tail.

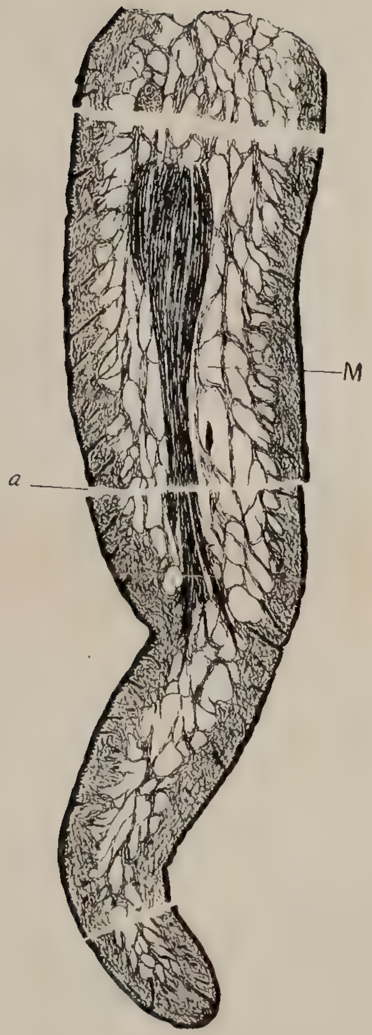

FIG. 4.—Frontal sections of tail, showing the arrangement of the muscle fibres (*M*). a, Place from which the cross-section represented in Fig. 5 was taken. × 3.

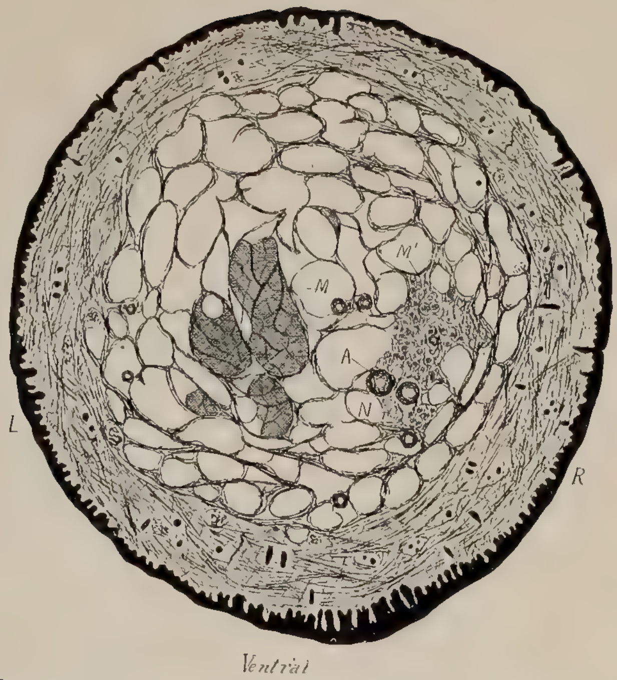

FIG. 5.—Cross-section through the middle of the tail (Fig. 4, a). M, muscle; *M′*, degenerating muscle; *A*, artery; *N*, nerve; *L* is placed on the left and *R* on the right of the appendage. × 9.

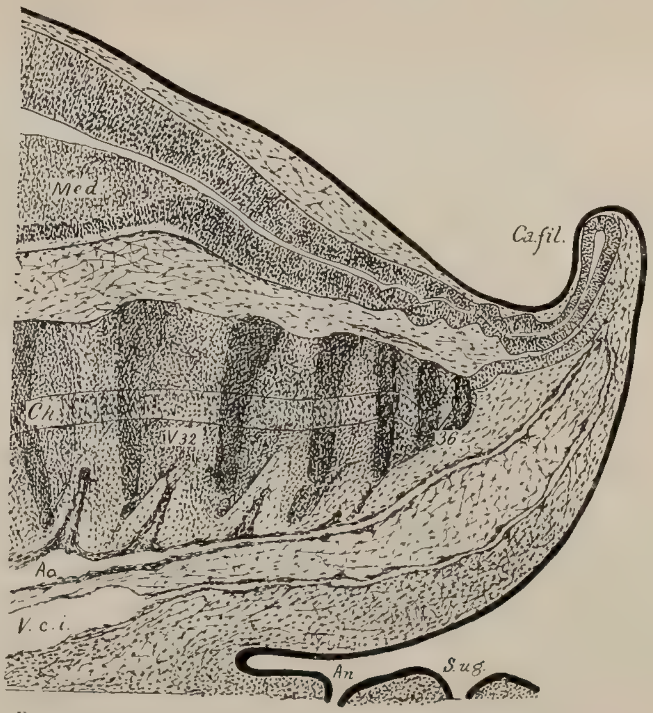

FIG. 6.—Caudal region of embryo of 14 mm. (No. 144 of Dr. Mall's collection), combined from several sagittal sections. *An.*, anus; *Ao.*, caudal aorta (*A. sacralis media*); *Ca. fil.*, caudal filament; *Ch.*, notochord; *Med.*, medullary cord; *S. ug.*, *sinus urogenitalis*; *V.* 32, third coccygeal vertebra; 36, seventh coccygeal vertebra; *V. c. i.*, caudal portion of *vena cava inferior* (*V. sacralis media*). × 91.

Harrison del

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